Using surgical sustainability principles to improve planetary health and optimise surgical services following the COVID-19 pandemic

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As the world faces crises instigated by environmental disruption, demands on healthcare require sustainable solutions.

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In this article, we outline the principles of sustainable surgery, how these can be used to optimise surgical services in light of healthcare crises, and how long-term adoption of these principles can help to reduce the carbon and plastic footprint of surgery in the UK and internationally. We describe how planetary and human health are closely related, including the relationship between environmental disruption and emerging infectious diseases.

IMPACT OF CLIMATE CHANGE ON HUMAN HEALTH

We are currently living in the Anthropocene, a geological era in which human activities are the primary determinant of our climate and environment. *The Lancet* Commission on Health and Climate Change previously described climate change as the greatest threat to human health in the 21st century and the 2015 report reframed this as the greatest public health opportunity, given that we can actively reduce our environmental impact and that actions taken can directly benefit health.[1]

Human health is dependent on planetary health, and it is threatened directly through extreme events such as droughts, flooding, storms and heatwaves as well as indirectly by the impact that climate change has on food production, air quality and ecologies.[1] In 2019, we saw widespread climate disruption (including European heatwaves, Australian bush fires and flooding in the UK) and air pollution remains the largest cause of global death, responsible for around 7 million additional deaths per year.[1]

Our interference with the natural world is linked to new and emerging infectious diseases, due to climate change (climate sensitive infectious diseases have been linked with changes in the geographical spread of vector-borne diseases, increased waterborne disease transmission following extreme weather events and biodiversity loss),[1] alongside our disruption of ecosystems and habitats (including novel interactions between humans and natural viral hosts as well as intensive farming practices). The majority (70%) of novel and emerging infectious diseases are zoonotic,[2] transmitted from animals to humans (sometimes subsequently mutating to enable human-to-human transmission). Recent zoonotic epidemics include variant Creutzfeldt–Jakob disease, bird flu, swine flu, Ebola, Middle East respiratory syndrome coronavirus (MERS-CoV) and severe acute respiratory syndrome coronavirus (SARS-CoV-1).

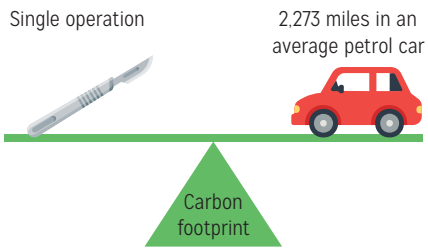
As we are all acutely aware, most recently, the emergence of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has led to the COVID-19 pandemic, with bats thought to be the viral species of origin. We are likely to see further zoonotic viral epidemics and climate related health crises if we continue our current trajectory of environmental disruption.[1]

IMPACT OF SURGERY ON GREENHOUSE GAS EMISSIONS

While damage to planetary health threatens public health, the provision of healthcare paradoxically compounds the problem. In England, the NHS is responsible for a quarter of all national public sector greenhouse gas emissions.[3] Carbon dioxide (CO_2) is the predominant greenhouse gas associated with healthcare (other greenhouse gases are converted to CO_2 equivalents [CO_2e] and summated) and the 2020 For a Greener NHS campaign commits the NHS to reach carbon neutrality by 2050, in line with the Paris Agreement.[4] The US healthcare industry alone is estimated to generate over 1.7 million tonnes of plastic waste per year and this is likely to rise given our increasing reliance on single-use plastics.[5]

A large proportion (59%) of the NHS carbon footprint is associated with the supply chain.[6] Operating theatres are major contributors to this as a resource intensive area of hospitals requiring large volumes of consumables and energy utilisation. Our systematic review found that a single operation generates between 6kg and 814kg CO_2e, with the largest figure equivalent to driving up to 2,273 miles in an average petrol car (Figure 1).[7] We identified that the major carbon hotspots in surgical operations are the procurement of consumables, electricity use and anaesthetic gases.[7]

Figure 1 The equivalence between the carbon footprint of a single operation and driving an average petrol car. Adapted from: Rizan *et al*.[7]



Human health and planetary health are interdependent. Increasing provision of healthcare (in line with an ageing population and medical advances) traditionally results in higher levels of healthcare sector greenhouse gas emissions, which paradoxically threaten health through direct and indirect climate related health impacts. The benefits of improving healthcare sustainability are manifold, in helping us to reduce our carbon footprint while improving our capacity to optimise healthcare provision during health crises, which may themselves be a result of climate change or environmental disruption (Figure 2).

PRINCIPLES OF SUSTAINABLE SURGERY

Many of us are trying to reduce the environmental impact in our personal lives (eg adopting active or green(er) travel, shifting towards plant-based diets, recycling and seeking to reduce plastic use in our homes) but we invite you to consider what actions surgeons can take to improve the environmental sustainability of their surgical practice, using the principles of sustainable surgery. These principles were designed to help maintain and improve health outcomes in the context of a radically reduced pool of resources due to climate disruption or climate mitigation measures. However, they are just as applicable in the context of COVID-19 and other health crises related to environmental disruption, where we

Figure 2 Relationship between healthcare and emerging zoonotic diseases, and the role of improving sustainability

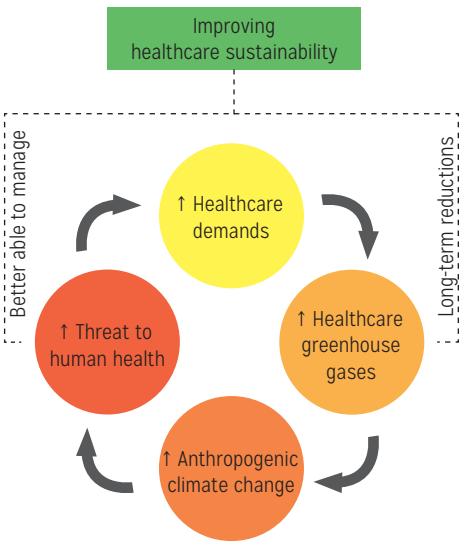
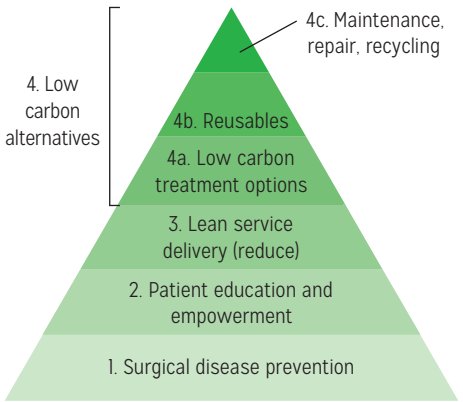


Figure 3 Principles of surgical sustainability



have limited resources available to us to treat surgical diseases (for example, owing to restrictions on operating and outpatient activity). These principles will be equally relevant post-COVID-19, especially given the anticipated backlog of elective surgical procedures.

Whenever we think about making changes to surgical services, it is helpful to target these around improving 'sustainable value', balancing patient and population outcomes against the triple bottom line (environmental, social and financial sustainability).[8] When focusing on the environmental aspect of the triple bottom line, it may be useful to apply the Centre for Sustainable Healthcare's four principles of sustainable clinical practice, adapted for a surgical setting in Figure 3.[8]

Surgical disease prevention

Society needs to place much greater emphasis on disease prevention overall and this is equally true for traditionally 'surgical' disorders. Demands on surgical services can be reduced through increased public health measures to expand disease prevention campaigns designed to encourage healthy behaviours such as reduced red and processed meat consumption, increased exercise, smoking cessation and alcohol moderation. Surgeons can collectively contribute to national policy debates and relevant public awareness campaigns, alongside collaborating at a local level with primary care colleagues to promote healthy behaviours in local populations.

Patient education/empowerment

Surgeons should lead education campaigns targetted at specific surgical patient groups, empowering patients to do what they can to optimise health and minimise risk, reducing the demand for surgery and also improving fitness for surgery if an operation is required. This may include disease specific lifestyle advice (eg encouraging weight-bearing exercise for those with osteopenia and supporting patients with alcoholic liver disease to abstain from alcohol) and many other surgical groups would likely benefit from these lifestyle measures too (together with smoking cessation and healthy diets) as part of preoperative optimisation.

Checking compliance with medications (eg steroids, immunosuppressants or biologics in those with inflammatory bowel disease) as well as medication rationalisation are other low carbon interventions with the potential to reduce the need for surgery. For example, patients with diverticular disease should avoid non-steroidal anti-inflammatory drugs, which are associated with increased risk of complications. Patients should also be reminded of how and when to seek medical assistance (with appropriate safety netting) to reduce unnecessary hospital visits, and general practitioners can help in this also through appropriate referral and escalation to secondary care. These approaches can provide co-benefits of improving health and wellbeing while reducing the environmental impact of surgical care.

Surgical disease prevention and optimisation are of particular importance given the current restrictions on surgical services due to COVID-19. They highlight the need for a fundamental shift in our definition of healthcare, away from treatment of disease, and towards promoting and maintaining wellbeing. Surgical patients should be made aware of the continuing uncertainty surrounding resumption of surgical services and this may improve engagement with disease optimisation initiatives.

Lean service delivery

Using lean management principles to streamline surgical pathways can help us to optimise resource utilisation (equipment, time, space, financial and workforce capacity). Lean service delivery involves streamlining surgical patient pathways, including minimising unnecessary outpatient appointments while reducing patient travel to hospital and associated disruption to work. Virtual clinics have been widely adopted during the COVID-19 pandemic and these should be considered on an ongoing basis for a subset of appointments. Lean models of surgical care have been shown to improve outpatient and perioperative efficiency while reducing costs,[9] and it is likely that they are also associated with carbon savings.

Consideration can be given to streamlining operations, primarily focusing on reducing the use of consumables. It is important to question the routine and 'just in case' culture, and to avoid opening or requesting items until they are clearly required. Surgeons need to be patient for the few moments it takes to open a piece of equipment that is not absolutely essential

to the procedure. In addition, we must question unnecessary packaging of surgical supplies and double wrapping where it is not indicated.

It is important also to remove single-use items that are used infrequently or not at all from sets prepared in advance. However, our own analysis indicates the reverse is true for sets of reusable instruments as a static amount of resources is used by decontamination machines for a given reusable set (usually at a fixed price), resulting in the paradoxical anomaly that streamlining these sets may not reduce the carbon footprint.

Low carbon models of care

The principle of low carbon models of care includes choosing treatment options with lower environmental impacts where clinically appropriate, alongside opting for products and processes with lower carbon footprints.

Low carbon treatment options

When looking at how to optimise entire patient pathways, we need to consider the clinical efficacy, financial costs, social implications and carbon footprints of various models of care. Focusing on clinical effectiveness can help to ensure that the environmental impact of healthcare is necessary rather than avoidable and it can reduce the need for further medical interventions (with their own associated carbon footprint). There may also be differences in the carbon footprint between alternative surgical approaches, with some evidence that minimally invasive operations have higher carbon footprints than traditional approaches, although studies to date have not taken into account the impact of alternative approaches on length of hospital stay or complication rates.[7]

Consideration should also be given to non-surgical alternatives and conservative measures, especially where an operation has limited effectiveness. For diseases with acute courses, the carbon footprint of medical treatment may be lower than operating (eg non-operative management of early appendicitis, as has been advocated during the COVID-19 pandemic). However, while surgery is initially resource intensive, it may have a lower net impact on resources when considering the longer term for chronic conditions. For example, Gatenby found that the carbon footprint of surgery for gastro-oesophageal reflux disease is lower than for medical treatment after nine years.[10] More should be done to explore this in other surgical settings to inform treatment choice.

These principles are consistent with the Getting It Right First Time programme, which seeks to minimise unexplained variation in the use of surgical interventions and to ensure that those that are used have clear evidence of benefit, with the addition of increasing the most efficient use of financial resources. This also aligns with the Choosing Wisely initiative, which encourages shared decision making, looking at patients' individual circumstances and their values about the outcomes that they would prioritise.

The principle of low carbon models of care includes choosing treatment options with lower environmental impacts where clinically appropriate, alongside opting for products and processes with lower carbon footprints

Reusable equipment

Studies examining reusable surgical instruments, linens and perioperative equipment found that the carbon footprint of reusable surgical items is lower than for single-use equivalents, modelled using life cycle assessments, and taking into account sterilisation and laundering (although the reverse was true in some Australian studies using coal-based electricity).[7] Our own analysis indicates that a small number of bulky single-use plastic items (eg single-use drapes and suction tubing) make significant contributions to the carbon footprint of operations. There are sometimes direct switches that can be made from single-use items to reusables (for instance, using rigid aluminium containers to house reusable instrument sets in preference to single-use tray wraps), and this reduces the carbon and plastic footprint, along with financial costs over time.

We should also be aware as surgeons that labour rights abuses have been widely reported in the supply chains of many single-use items, including surgical masks, gloves and instruments used in the UK.[11] Many of these items are produced under forced working conditions in countries such as Pakistan, Malaysia and Mexico, and there are reports of children as young as seven years working in the surgical instrument industry.

The UK government advises that reusable instruments and devices should continue to be decontaminated as normal during the COVID-19 pandemic.[12] Given that SARS-CoV-2 is inactivated in a similar manner to other human coronaviruses (including by heat, extremes of pH, sunlight and common disinfectants), the novel virus should not affect our use of reusable surgical equipment.

Where it is clinically inappropriate or unfeasible to use reusable items, we can also consider using 'resposable' surgical devices (reusable items with single-use components), alongside reprocessing of single-use items, which is common practice in the US but not widely used in the UK. Single-use items should generally be reserved for where there is evidence demonstrating the infection (or other) risk associated with reusable equivalents or where no reusable equivalent is available. For example, at present, our only option for certain personal protective equipment (PPE) is to use single-use items (eg gloves and filtering facepiece respirators). We have reusable fluid resistant gowns, eye visors and face shields available in the healthcare setting but do not currently have sufficient supplies (or decontamination infrastructure) to allow widespread use owing to the recent surge in demand.

There is a growing body of research and enterprise seeking to develop safe and scalable reusable PPE. The ability to decontaminate PPE while maintaining protection efficacy remains challenging but development should be encouraged, together with reusable alternatives for other products traditionally only available as single-use items.

Maintenance, repair and recycling

Finally, given finite global resources, we need to apply circular economy principles whereby we maximise resource use through maintenance, repair and recycling in order to extend the lifespan of our consumables and capital goods. Every relevant individual (including surgeons, staff in sterile service departments and perioperative staff) should be encouraged to look after our equipment and actively monitor these for defects. Most trusts have repair contracts in place but these are often underused. A large proportion of waste generated in theatres is potentially recyclable and more should be done to facilitate this. Although waste poses a significant logistical and environmental challenge, it only contributes a very small proportion to the carbon footprint of healthcare (0.1% of the total NHS carbon footprint)[6] and is therefore not covered in this report.

CONCLUSIONS AND FUTURE STEPS

Human health and planetary health are interdependent, and we need to protect the environmental systems on which human health depends. Human interaction with our natural environment has resulted in climate change and emerging infections.[1] We can use the principles of sustainable surgery to help manage dynamic healthcare demands during environment related healthcare crises including zoonotic epidemics. Surgical sustainability should be improved on an ongoing basis to help meet carbon reduction targets and minimise our environmental impact.

According to the sustainable surgery principles, surgical disease prevention should be prioritised, followed by working with patients to optimise their health and surgical conditions. Surgical services can be optimised using lean service delivery and consumable use should be minimised. We should switch to low carbon alternatives where possible, including low carbon treatment options when clinically appropriate, using reusables where possible, and apply circular economy principles to extend the lifespan of our surgical equipment.

There is no simple solution to surgical sustainability and we all need to play our role through multiple small acts while pushing for institutional change at local and national level. We need centralised guidance on how to redesign sustainable surgical systems using lean principles and low carbon alternatives, including guidelines on environmentally preferable equipment and processes. This should be benchmarked on best practice, taking into account the triple bottom line, and may help to reduce unwarranted variation in surgery and improve surgical outcomes.

We need to apply circular economy principles whereby we maximise resource use through maintenance, repair and recycling

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